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Intermediate Tailings Disposal Facility (ITDF)
East Starter Dam
Technical Report and Permit Application

IGES Job No. 01640-002

February 13, 2014

Prepared for:

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1.0 EXECUTIVE SUMMARY

The site owned and operated by CS Mining is located approximately 8 miles northwest of Milford, in Beaver County Utah. Additional long term tailings storage capacity will be required to continue operations. The expansion will consist of phased construction of a new tailings impoundment located approximately 1/2 mile southeast of the beneficiation facility. The areas proposed for development are located in two small drainages east of the existing plant site. Proposed development will consist of two impoundments (West and East) collectively known as the Intermediate Tailings Disposal Facility (ITDF) constructed with starter dams and subsequently raised using upstream construction methods. This permit application will focus only on the east starter dam and discuss future development of the ITDF with the second starter dam and subsequent raises for informational purposes.

Construction of the ITDF is to be broken up into four distinct phases. Starter dams will have 3 horizontal:1 vertical (3H: 1V) upstream/interior slopes and 2H:1V downstream/exterior slopes and will be fully lined with a smooth 40 mil high density polyethylene (HDPE) liner. Subsequent upstream raises will have 1.5H: 1V upstream slopes and 2.5H: 1V downstream slopes and are designed to be lined with a geocomposite liner (GCL). The GCL will also line the raised sideslopes of the impoundments and transition to a HDPE liner in the areas projected to contain supernatant (free waters) prior to recovery and recycle to the mill. For upstream raises, a geofabric will be placed atop the tailings beach to facilitate initial raise fill placement functioning to both separate and minimize tailings displacement during initial fill placement.

All the embankments associated with the proposed impoundment will consists of locally derived soils and have a 20 ft. wide crest for vehicle access. Source of borrow soils to be used for the proposed starter dams and subsequent expansion will be developed within the proposed impoundment basin and immediately north and slightly west of the existing facility. All borrow materials will be composed of residual, highly weathered and decomposed granodiorite that underlie the ITDF sites and the adjacent areas. Portions of the borrow material will be developed from a ridge area that separates the two drainages.

Clarified supernatant will collect in the pond before recycle and reuse in plant processes. Impounded clarified waters will be recovered and pumped back to the beneficiation facilities using the same or similar floating barge and piping system currently being employed at the existing tailings operations.

The purpose of this report and Permit Application is to demonstrate the technical feasibility of the proposed impoundment facilities and present detailed engineering plans supporting the proposed design approach.

NOTICE: The scope of services provided within this report are limited to the assessment of the subsurface conditions at the subject site. The executive summary is provided solely for purposes of overview and is not intended to replace the report of which it is part and should not be used separately from the report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical investigation and analyses conducted for the proposed expansion of CS Mining's tailings management operations through the development of a new facility designated as the Intermediate Tailings Disposal Facility (ITDF). A site investigation of site stratigraphy and geotechnical characterization of the proposed borrow materials was performed as a basis for development of the proposed design. Analysis of existing tailings beach materials from the flotation tailings pond was performed by IGES as presented in their report dated June 13, 2013, relevant portions of which are included as an appendix to this submittal. This expansion design will serve as the basis for the application for a new Ground Water Discharge Permit and associated construction permit to be administered by The Utah State Department of Environmental Quality, and an application for a Dam Safety Permit to be issued by the Utah State Engineer, Division of Water Rights. The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report.

2.2 PROJECT DESCRIPTION

The ITDF will be developed sequentially by construction of the east starter dam followed by the west starter dam as tailings are initially placed to the east, then west of a natural ridge which separates two basins. Tailings will be placed in the east basin during construction of the west basin. A series of 10 ft raises will be constructed atop each of the starter dams as the basins fill with tailings. After tailings fill reaches an elevation of 5815 ft, the two separate basins will function as a single larger basin. The combined facility will ultimately occupy approximately 72 acres in total and have the capacity to contain 6.7 million tons of mill tailings. Tailings will be deposited into the impound using a managed discharge approach in order to build a tailings beach along the upstream dam faces to allow expansion using upstream methods with four subsequent 10 ft. raises. This approach to managed deposition will cause the clarified supernatant pool to be developed in the northern reaches of the basin(s) where clarified waters will be recycled to the mill using a floating barge pumping system similar to that currently employed at the existing tailings operations.

The proposed ITDF development will be sequential, initiating with development of the east drainage starter dam and basin lining. The east starter dam will be constructed to a crest

elevation of El. 5820' and have a minimum crest width of 20 feet. Downstream slopes will be 2H:1V with upstream slopes constructed at 3H:1V to facilitate lining. The basin liner will be fusion welded smooth 40 mil high density polyethelene (HDPE). Side slope of the basin will be graded to 3H:1V or flatter in order to develop borrow for starter dam construction and facilitate liner deployment and installation. The exposed decomposed granodiorite will be graded and compacted to form a suitable base for liner installment.

Portions of a ridge that currently separates the east and west drainages that form the ITDF will be excavated as an additional source of borrow material for the east starter dam. The entire east basin will be grubbed to remove existing vegetation. The thin veneer of topsoil and underlying residuum approximately 12 inches in thickness will be removed and stockpiled for future reclamation activities. The foundation within the dam footprint will be overexcavated to between 5 and 12 feet, extending to the underlying weathered bedrock, placed and recompacted to form a structural foundation for the starter dam.

A perimeter road will be cut at the perimeter of the impoundment to facilitate liner installation and anchor trench development as well as future line expansion and early tailings facility access. Ultimately an access road will extend around the facility for maintenance purposes, pipeline management and subsequent raise development. The road around the north perimeter of the ITDF will facilitate installation and maintenance of the required tailings distribution and recycle water pipeline. The upslope edge of the road will form a channel to divert and manage upland surface water runoff from the approximate 84 acre watershed. Incident precipitation will be contained within the ITDF.

Perimeter discharge of the tails would commence from the starter dam crests to facilitate upstream raises, thereby creating a clarified pool to the north while allowing tailings adjacent to the embankments to dry out. Key physical parameters for the initial phases of the proposed ITDF construction are summarized in the following table.

Parameter	Units	East Dam	West Dam	Combined ITDF
Maximum Starter Dam Height	Feet (elev)	111 (5820')	48 (5830')	
Starter Dam Fill Requirement	c.y.	415,000	151,000	566,000
Initial capacity	c.y.	1,181,600	465,600	1,584,200
Initial Basin Area	acres	29.8	17.2	47
Upslope Diverted Drainage Area	acres	11.2	72.7	83.9

3.0 METHODS OF STUDY

3.1 GEOLOGIC INVESTIGATION

The geologic conditions for the general area have previously been investigated and discussed by R. J. Bayer, P.G.[1] (2014) in the GWDPA and are included herein by reference.

3.2 SUBSURFACE INVESTIGATION

Geotechnical conditions were explored throughout the site, locations are shown on the Exploration Location Map on Plates A-2a and A-2b. Three borings were advanced by IGES, Inc. to obtain rock cores of Granodiorite and evaluate competency of near surface bedrock. IGES borings were advanced from 35 to 50 feet below ground surface (bgs). One additional boring was advanced by CS Mining to evaluate deeper rock characteristics to 200 feet bgs. 36 Test Pits were excavated with a backhoe. Geophysical surveys were conducted to evaluate continuity of surficial soils and quality of bedrock based on Shear Wave Velocity. One study was conducted atop the ridge that separates the east and west basins to investigate the feasibility to excavate these materials as a borrow source for dam construction. Results of the survey indicate that suitable borrow may be developed in the ridge area to a depth of 20-30 feet or more without the need to blast. A second shear velocity profile survey was conducted beneath and downstream of the east starter dam footprint to confirm foundation competency.

Site soils are generally Well to Poorly Graded SAND with silt or Silty SAND in the upper 8 to 10 feet. The surficial soils are underlain by a highly weathered Granodiorite grading to competent bedrock at approximately 30 feet.

IGES Inc. conducted the subsurface investigations of potential borrow sources on March 7, 2013, March 26, 2013, and August 7, 2013. Exploration of the subsurface soil was accomplished by excavating test pits in potential borrow areas. Test pits were excavated by CS Mining staff under the direct supervision of IGES with test pits being logges by IGES and samples being taken for future laboratory evaluation. All test pits were backfilled using excavated materials at the conclusion of logging and sampling. Bedrock conditions were investigated by IGES by advancing borings B-1 through B-3, from which rock cores were obtained, on August 13, 2013.

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[1] Ground Water Discharge Permit Application for CS Mining, LLC, Solution Ponds and Intermediate Tailings Disposal Project, January 30, 2014 prepared by R. J. Bayer Professional Geologist, LC..

Geophysical surveys were conducted on August 20 and December 3, 2013. Surveys confirmed that site soils extended to approximately 8 to 10 feet below ground surface, underlain by highly weathered bedrock grading to competent bedrock at approximately 30 feet below site grade. The approximate locations of the explorations completed are shown on the Exploration Location Map (Plates A-2a and A-2b). The materials encountered during our investigations are presented on the Boring Logs, Plates B-1 through 4 and on the Test Pit Logs, Plates B-5 through 40. The key to USCS Soil Symbols and Terms and the Key to Rock Properties are located on Plate B- 41 and 42. Geophysical Survey results are presented in Appendix B.

Bulk samples were obtained from the materials encountered in the test pits. Bulk bucket samples of potential borrow materials were collected in 5 gallon buckets and sealed with air tight lids for preservation. All investigation activities and sampling were performed under the direction and supervision of an experienced IGES geotechnical engineer, with the exception of the ITDF boring performed by CS Mining.

3.3 LABORATORY INVESTIGATION

In order to assess the stability of proposed embankments, site stratigraphy and strength properties of borrow materials were determined. Representative soil samples were tested in the laboratory to evaluate pertinent physical and engineering properties. Laboratory soil tests consisted of moisture, gradation analyses, Atterberg limits tests, laboratory compaction, triaxial compression, direct shear, pinhole dispersion and hydraulic conductivity tests to aid in characterizing the soils and to develop design parameters for our stability and seepage analyses and for correlation purposes. Strength tests were performed on recompacted bulk samples of proposed borrow materials. The results of the laboratory tests are presented in Appendix C.

Bulk bag and bucket samples were taken from the test pits. Samples were preserved in the field and returned to the laboratory for confirmatory classification and laboratory testing. Moisture density relationships were developed according to the standard Proctor method (ASTM D698B). Bulk samples were remolded to simulate constructed site conditions for use in strength, permeability, and dispersion testing. A series of strength tests were performed on recompacted and remolded bulk samples of potential borrow fill. Consolidated Undrained with pore pressure measurements (CUPP) triaxial tests were performed to determine total stress and effective stress strength parameters. Direct shear tests were performed to determine the effective friction angle (ϕ') and cohesion intercept (c') of selected samples.

4.0 GEOLOGIC CONDITIONS

4.1 GEOLOGIC SETTING

The site is located immediately south of the Beaver Lake Mountains within the Warm Springs-Pioche-Marysville Mineralization Belt (Rowley, et al, 1979). Surficial soils are primarily composed of decomposed Granodiorite, overlying highly weathered grading to competent Granodiorite. The project area can be described as having 2 to 12 feet of alluvium overlying diotitic bedrock. Some faulting exists in the area, but no evidence of faulting in the area is reported in the literature or by CSM geologists.

Location of the site is at Latitude N 38E 28' 51", Longitude W 113E 07'03"

There is no surface water, with the exception of that contained within the existing tailings impoundment, in the general area. Other than minor groundwater in fractures, groundwater is reported to be at depths greater than 100 feet.

4.2 SEISMICITY

The spectral accelerations mapped as a part of NEHRP/NSHMP generally correspond to a "firm rock" site, known as Site Class B. To account for site effects, the PGA is typically modified using a site coefficient that varies with the magnitude of spectral acceleration, distance to seismic source, and the harmonic mean of the shear wave velocity of earth materials in the upper 30 meters, V_s^{30}.

Based on available laboratory data and estimated shear wave velocities the soils underlying the site are classified as Site Class C ("very dense soil and soft rock").

The 2PE50 accelerations were calculated with the aid of the USGS Seismic Hazard Curves and Uniform Hazard Response Spectra v. 5.1.0 application. Data from the probabilistic hazard curve for the 2% probability of exceedance in 50 years was used to calculate the acceleration for evaluating seismic stability of the proposed impoundment expansion. The 2PE50 ground motion for the site, corrected for site class, has been established as 0.26 g. Details of this analysis are included in the Appendix on Plate E-1.

4.4 OTHER GEOLOGIC HAZARDS

Geologic hazards can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. The only potential geologic hazard relevant to the proposed facility modification is liquefaction. This potential hazard is addressed in the following section.

4.4.1 Liquefaction

The nature of the gradation for the hydraulically placed tailings makes them susceptible to liquefaction under design seismic conditions. The limited performance life required of the proposed expansion; i.e. 4 to 8 years, eventual drainage of the tailings and reclamation of the site makes the potential impacts of liquefaction of the tailings supporting the proposed raise of the impoundment of minimal concern. Liquefaction of the impounded tailings will have no effect on the lined starter dam embankment structures.

5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

The surface of the site is generally sandy with occasional rocky outcrops. The site is well-drained with poor vegetation cover. The Milford Utah area is typically warm and dry in the summer and cold and dry in the winter, as indicated by precipitation records and by the sparse vegetation on site. The 100 year storm over a 24 hour period will consider the peak maximum precipitation for the site at 2.99 inches.

The site slopes towards the center of the proposed east tailings dike at a 10 to 35% grade, then trends toward the southeast. An intermittent drainage is located in the center of the proposed tailings impoundment. The ephemeral drainage channel is down the center of the proposed tailings impoundment and is the outfall for the watershed in which the tailings impoundment is located. Surface water runoff that may develop from the watershed upslope of the ITDF will be diverted by a shallow V-shaped ditch that will run along the upstream edge of the access road/pipeline corridor between the mill and the ITDF.

5.2 SUBSURFACE CONDITIONS

5.2.1 Soils

Subsurface conditions beneath the site are described and discussed in GEM[2] (2009).

Test pits excavated to characterize the potential borrow area proposed for embankment raise construction encountered approximately 6 inches of sandy silt with a thin root mat that can be characterized as "topsoil". This veneer of "topsoil" was typically underlain by a medium dense, poorly graded silty sand classifying as an SM to SP-SM, based on the Unified Soil Classification System (USCS). These near surface sands contained some gravel and cobble sized rock fragments of weathered rock and transitioned to the underlying bedrock (granodiorite) generally at depths ranging between 6 and 7 feet.

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[2] Mill Tailings Impound Basin, Technical Report and Permit Application, prepared for Western Utah Copper, Report Number RE0106 by GEM Engineering, Inc. dated September 2, 2009.

5.2.2 Bedrock

Depth to bedrock varies across the site ranging from 2 to 15 feet below ground surface. Similar conditions were found within the proposed borrow area within the impoundment. Weathered bedrock was composed of a Granodiorite overlain by a completely decomposed mantel of this parent rock characterized as a sand with gravel (SP-SM). A thin veneer of sandy silt with gravel covers these residual soils and weathered bedrock.

5.2.3 Groundwater

Depth to groundwater at the site was previously reported by GEM[3] (2009) to between 100 to 250 feet below the base of the impoundment.

Groundwater was not encountered in any of the explorations performed by IGES, Inc. CS Mining also performed a boring to 200 feet at the tailings dam site and groundwater was not encountered. The starter dike and base of the pond is designed to be fully lined to minimize infiltration of tailings impoundment water into the basin subsurface.

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[3] Mill Tailings Impound Basin, Technical Report and Permit Application, prepared for Western Utah Copper, Report Number RE0106 by GEM Engineering, Inc. dated September 2, 2009.

6.0 ENGINEERING ANALYSIS AND DESIGN RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

Supporting data upon which the following recommendations are based have been presented in the previous sections of this report and laboratory data. The recommendations presented herein are governed by the physical properties of the soils encountered in the exploratory test pits, borings, and surveys, and the anticipated construction. If subsurface conditions other than those described herein are encountered in conjunction with construction, and/or if design and layout changes are initiated, IGES must be informed so that our recommendations can be reviewed and revised as changes or conditions may require.

Based on the subsurface conditions encountered at the site, our literature review of geologic hazards and our engineering analysis, it is our opinion that the proposed construction can be completed provided the designs and recommendations contained within the following sections and attached drawings are properly implemented during construction. We recommend that IGES, Inc. be involved during the construction to see that the recommendations contained in this report are complied with.

6.2 EARTHWORK

General site grading will be required for the proposed expansion. The primary concerns during the earthwork for the project are that perforation of the HPDE liner material is prevented, a firm foundation for starter dike is established, and the amount of fill displacement during upstream raise construction is minimized. The uppermost 12 inches of soil and residuum within the proposed basin, dam, and borrow area designated as topsoil should be stripped and stockpiled for use in future reclamation activities.

6.2.1 General Site Preparation and Grading

The tailings impoundment basin must be grubbed of all vegetation. Grading should be performed to eliminate all protrusions that may perforate HDPE liner material. Sharp rock or other deleterious materials exposed at the graded surface that could cause such perforations should not be allowed to contact with liner material. Perform basin grading and liner placement in conformance to manufacturer recommendations.

Areas beneath the proposed starter dikes should be grubbed of topsoil and all vegetation. Before placement of starter dike structural fill, the subgrade should be prepared to provide a firm foundation. The subgrade should be benched to provide a horizontal plane for compaction, scarified to 8 inches, moisture conditioned, and compacted. Subgrade should be compacted to at least 95 percent of the maximum dry density, as determined by Standard Proctor (ASTM D-698). The moisture content should be within +/- 2 percent of optimum water content at the time of compaction as determined by ASTM D-698.

Site preparation for future raises on the tailings beach will be limited because of the relative softness of the wet materials. Prior to placement of an initial 12 to 18 inch layer of fill soils on the beach, use of a geofabric as a separation and stabilization material will be required. Installation of a 270 lb/in (ultimate strength ASTM D-4595 basis) woven slit film geofabric such as Comtrac P45.45 by Huesker, Inc. or equal will be required to facilitate initial fill material placement spanning the entire width of the raise fill. The fabric will be extended up the upstream face of the existing embankment and suitably anchored at the crest. Required panel width of geofabric will require field sewing to attach adjoining fabric panels beneath the entire raise fill width. Initial fill placement will require the use of low ground pressure tracked equipment and not be suitable for direct fill placement until an initial 4 ft. layer has been developed.

6.2.2 Structural Fill and Compaction

Fill placed in conjunction with development of the tailings impoundment will consist of compacted structural fill from designated borrow sites. Structural fill should be placed in maximum 8- inch loose lifts and compacted on a horizontal plane, unless otherwise approved by the Geotechnical Engineer. Structural fill should be compacted to at least 95 percent of maximum dry density at ±2 percent of optimum water content at the time of placement as determined by ASTM D-698. Borrow materials should be approved prior to importing.

For upstream raises the initial 12 to 18 inches of fill should be comprised of approved borrow material placed on geofabric. However, based on IGES experience with similar projects, borrow material cannot be compacted to the specified requirements of structural fill due to the limited stability of the underlying tailings. These materials will only be subject to compaction via trafficking of the placement and spreading equipment. A minimum of three passes will be required. Also, prior to placing fill, the placement of the geofabric including seaming (sewing)

and anchorage should be observed by IGES, Inc. to confirm that materials have been properly placed, sewn and anchored.

6.3 SURFACE WATER HYDROLOGY

On site there are no perennial streams or surface water. The Sevier Lake Playa and the Beaver River are the nearest bodies of surficial water. The probable maximum precipitation (PMP) estimate for the site is relatively low, with an upper bound value of 2.99 inches for a 100 year 24 hour storm.

Surficial soils are generally poorly graded SAND to Silty SAND composed of decomposed Granodiorite bedrock. Surficial soils extend to highly weathered bedrock at 2 to 15 feet below ground surface. Competent bedrock was encountered in the on-site explorations and geophysical surveys at approximately 30 feet below ground surface. In situ site soils and highly weathered bedrock are assumed to be sandy and well-drained.

The site may be considered an arid or semiarid region of the Great Basin Drainage. Observations of surface conditions support an estimate of less than 30 percent desert shrub vegetation on-site.

Site topography is somewhat mountainous with grades approaching 35%. The tailings pond is located at a location and grade such that there is 101 acres upslope watershed running onto the final design tailings pond of approximately 60 acres. Utilizing the Urban Hydrology for Small Watersheds Technical Release (TR-55) method it is estimated that the upslope watershed could potentially contribute approximately 0.42 inches per acre of runoff of the 2.99 inches per acre considered in the design. Assuming the PMP of 2.99 inches is retained in the tailings pond, the run-on from the upstream watershed could potentially contribute 0.75 additional inches of water to the ITDF. Details of the TR-55 analysis are presented in the Appendix on Plates D-1 through 6.

In order to intercept run-on water a ditch is proposed to convey stormwaters around the pond perimeter. An access road will be constructed around the perimeter of the pond with the ditch on the upstream side of the road. If the road is constructed such that it crests on the saddle on north side of the pond at 5900' and daylights on the east and west side of the proposed dike at elevation 5860', the watershed affecting the pond will be reduced to approximately 84 acres. The 84 acres of runoff should be intercepted by the ditch with channel side slopes of 4H:1V, a bottom width of 1 foot, and a minimum depth of 1.5 feet. The design storm should generate a potential

maximum discharge of 21 cubic feet per second with armored outfalls on the east and west end of the dikes to permit drainage discharge on the native surface of the existing hillsides. The proposed alignments of the ditches are shown on Sheet D-8.

6.4 ANALYSES OF DIKE GEOMETRIES

6.4.1 Interpretation

Slope Stability analyses were performed on the east and west dike geometries under various loading conditions. IGES, Inc. performed the analyses assuming the dikes are to be constructed primarily from on-site soils. Appropriate borrow soils were identified in all test pits performed by IGES. The basin of the tailings pond impoundment will be stripped of suitable dike construction materials before impoundment in each area begins.

Both the eastern and western dikes will consist of two phases, a starter dike to 5820' and a series of 10 feet upstream raises to 5860'. Typical starter dike construction is designed to have dike raises on the downstream side and 2H: 1V downstream slopes and 3H: 1V upstream slopes to 5820'. Upstream raises will be constructed with 2.5H: 1V downstream slopes and 1.5H: 1V upstream slopes. The basin and starter dike will be lined with 40 mil smooth HDPE, and GCL is planned to line the upstream side of upstream raises.

Based on our experience at the CS Mining site and at a number of other similar impoundments, it is our professional opinion that upstream construction methods can safely and economically be employed to construct the 10 feet raises proposed on the starter dike embankments. The use of moderate strength geofabric is recommended to limit beach material displacement.

6.4.2 Seepage Analyses

For the purposes of stability modeling, the groundwater surface used in the analyses was based on the finite element program SEEP 2D within the SLIDE software using estimated coefficients of permeability for both the tailings and dike soils. The following summarizes the general stratigraphy and material properties assigned for the analyses of the proposed starter dike and upstream raises. The seepage surface is calculated based on the assumption that conditions are in a steady state. Values for the coefficient of permeability shown below were adapted from

permeability tests on laboratory compacted samples and engineering judgment. Values assigned to the model used to calculate the seepage surface are presented in the following.

Upstream beach – normally consolidated tailings– SM/ML

Coefficient of permeability – k – 1.0×10^{-4} in/s

Silty Sand – overlying residual soils

Coefficient of permeability – k – 1.2×10^{-4} in/s

Dike Fill – borrowed site soil

Coefficient of permeability – k – 1.2×10^{-5} in/s

For long term analyses on the proposed starter dikes, the water surface in the pond was assumed to be 2 feet below the top of the starter dike at 5820'. An additional long term model of stability and seepage was also modeled with the phreatic surface at 2 feet below the proposed dike elevation at the maximum design storage level for the raise at 5860'. This level was used to model the slope stability and seepage analysis for the End of Construction (EOC) period of the construction sequences. The phreatic surface is shown in the slope stability models as a blue line that lies on the tailings surface and is confined by the proposed liner.

Seepage losses from within the basin are estimated to be de minimus since the entire initial phase of the basin will be lined with 40-mil HDPE.

6.4.3 Stability Analyses

Laboratory data was reviewed to select representative material properties for modeling the dike sections selected for stability analyses. Foundation stratigraphy was depicted using the results obtained from the soil logs. Soil properties for the dikes, tailings, and native material were generalized from laboratory testing conducted and summarized in Appendix E. The following summarizes the general stratigraphy and material properties assigned for the analyses of the starter dam and raises.

Tailings – normally consolidated

Total unit weight – 128 pcf

Effective ϕ' – 30 degrees

Total ϕ – 27 degrees

Effective and Total cohesion – 0 psf

Dike Fill – Borrow

Total unit weight – 130 pcf
Effective ϕ' – 37 degrees
Total ϕ – 14 degrees
Effective cohesion – 100 psf
Total cohesion – 1600 psf

Native Soils

Total unit weight – 123 pcf
Effective ϕ – 35 degrees
Effective cohesion – 100 psf

Bedrock

Total unit weight – 140 to 150 pcf
Effective ϕ – 35 degrees
Effective cohesion – 800 to 2000 psf

Analyses

Slope stability analyses were performed using the software program SLIDE 6.025 from RocScience. Strength parameters were developed for the generalized stratigraphic profile based on the investigation and testing performed. In order to determine tailings and dike fill strength properties, direct shear and triaxial tests of remolded samples from test pits were used to determine the mean friction angle.

Two cross-sections were analyzed, cross-section A-A' of the eastern dike at its highest and cross-section B-B' of the western dike at its highest. The cross-sections were selected to represent the most critical dike geometries.

Pseudo-dynamic analyses were performed to evaluate stability under earthquake conditions. For a 2 percent probability of occurrence in 50 years or an approximately 2,400 year return period event, a Peak Ground Acceleration (PGA) of 0.26 g can be calculated for the site, assuming a site

class C designation. A 50% reduction in the PGA was made per recommendations by Hynes and Franklin[4] and others to account for time response effects resulting in a design PGA of 0.13 g.
A number of slope stability cases were analyzed to evaluate the proposed geometries. The starter dike to 5820' and proposed raises to 5860' were analyzed in a long term steady state condition. The upstream raises to 5860'were evaluated downstream using the pseudo-dynamic condition to evaluate dike behavior under unlikely earthquake loading. The downstream and upstream slopes of the dike were evaluated using end of construction (EOC) total stress parameters A summary of the various cases evaluated and the resulting factors of safety determined using SLIDE 6.025 are summarized in Table 1.

Table 1 – Summary of Slope Stability Modeling

Description of Analysis Case	Static or Seismic	Failure Scenario	Long Term or EOC	Freeboard (ft)	Factor of Safety	Plate Number
Section A-A' – Raise to 5820'	Static	Downstream	Long Term	2	1.7	E-2
Section A-A' – Raise to 5860'	Static	Downstream	Long Term	2	1.7	E-3
Section A-A' - Raise to 5860', Seismic	Seismic	Downstream	Long Term	2	1.2	E-4
Section A-A' - Raise to 5860' EOC	Static	Downstream	EOC	2	1.7	E-5
Section A-A' - Raise to 5860', upstream EOC	Static	Upstream	EOC	10	5.8	E-6
Section B-B' – Raise to 5820'	Static	Downstream	Long Term	2	2.1	E-7
Section B-B' – Raise to 5860'	Static	Downstream	Long Term	2	1.8	E-8
Section B-B' - Raise to 5860', Seismic	Seismic	Downstream	Long Term	2	1.3	E-9
Section B-B' - Raise to 5860' EOC	Static	Downstream	EOC	2	1.9	E-10
Section B-B' - Raise to 5860', upstream EOC	Static	Upstream	EOC	10	7.5	E-11

Ten (10) foot raise configurations were evaluated for upstream static and pseudodynamic raises. Slope geometry for the slope using borrow incorporated a minimum 1.5H:1V upstream slope and a 2.5H:1V downstream slope. All crest widths would be 20 feet. A biaxial, 270 lb/in ultimate

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[4] **Hynes-Griffin and Franklin 1984,** Hynes-Griffin, M. E., and Franklin, A. G. 1984. "Rationalizing the Seismic Coefficient Method," Miscellaneous Paper GL-84-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

strength (ASTM D-4595 basis), woven, geofabric was used in supporting the upstream fill in the analyses.

As the results of the analyses presented in the Appendix in Plates E-2 through 11 all long term static minimum factors of safety calculated are greater than 1.5 and those under design pseudodynamic conditions are greater than 1.1.

6.5 DESIGN RECOMMENDATIONS

Recommended phases of construction are shown on the attached Design Drawings.
Phase I should consist of a starter dike to 5820' in the east drainage of the impoundment. The basin and upstream face of the impoundment should be lined with a HDPE liner.

Phase II should likewise consist of a starter dike to 5820' in the west drainage of the impoundment. It will likewise be lined with an HDPE liner which will extend eastward over the top of the ridge between the two basins.

A crest width of 20 feet is recommended to facilitate implementation of wheel berms and trafficability for maintenance equipment. A downstream slope of 2H: 1V, and an upstream slope of 3H:1V or flatter to facilitate liner installation is recommended for the starter dike. IGES, Inc. recommends a 40 mil HDPE liner similar in composition and characteristics to that used in the existing impoundment pond.

Phases III and IV should be a series of upstream raises constructed first on the east starter dike to an elevation of 5830', each subsequent raise will increase the elevation of the entire dam by 10 feet . The upstream face of the upstream raise should be lined with a GCL liner.

Upstream slopes in the GCL lined area will be constructed using a 1.5H:1V slope whereas the downstream slopes will be 2.5H:1V slope (see drawings in Appendix G for delineation of this typical section use).

Before starter dike ultimate storage capacity is reached, tailings discharge should be modified to facilitate future upstream expansion of the impoundment. The discharge pipeline should extend along the embankment crest. Discharge points need to be valved into the pipeline to facilitate managed distribution of tailings along the upstream face of the raised embankment.

Surface water (potential run-on) should be diverted away from the impoundment by means of a ditch. The ditch will bound the upslope perimeter of the proposed impoundment along the northern limits of the basin. The ditch will be on the upstream side of the proposed maintenance road. The ditch should be constructed such that it has 4 Horizontal to 1 Vertical side slopes, a 1 foot bottom width, and a 1.5 foot depth. Ditch geometry can be cut from existing site soils or built up with recompacted site soils.

Specifications for construction of the proposed raise are provided in Appendix F. The attached set of Design Drawings on Sheets 1 to 9 in Appendix G have been developed to depicting the proposed expansion design.

7.0 CLOSURE

7.1 LIMITATIONS

The recommendations contained in this report are based on our limited field exploration, laboratory testing, and understanding of the proposed construction. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible that variations in the soil and groundwater conditions could exist between the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, our firm should also be notified. This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

It is the Client's responsibility to see that all parties to the project including the Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

7.2 ADDITIONAL SERVICES

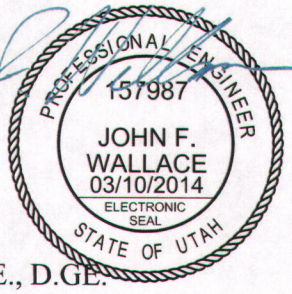
The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction. IGES staff should be on site to verify compliance with these recommendations. These tests and observations should include, but not necessarily be limited to, the following:

- Observations and testing during site preparation, earthwork and structural fill placement.
- Consultation as may be required during construction.
- Quality control and observation of fill placement and liner construction.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience (801) 270-9400.

Respectfully,

IGES, Inc.



John F. Wallace, P.E., D.GE.

Principal